Impact of hyperspectral infrared sounders in Numerical Weather Prediction models of Meteo-France

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As of early 2010, the operational global spectral forecasting model of Météo-France called "ARPEGE" runs four times a day with 60 levels in the vertical and a variable T538 horizontal resolution enabling a 15 km grid resolution over France, decreasing to 90 km at the antipodes. The data assimilation system is a Four-Dimensional Variational scheme (4DVAR), performed on 6h time windows. Météo-France also operates a 3DVAR assimilation (6h cycling) to initialize a limited-area model called "ALADIN-FRANCE" at 9 km horizontal resolution and a new fine-mesh model called "AROME" at 2.5km horizontal resolution over France. IASI and AIRS, respectively onboard the European MetOp and US Aqua polar orbiting satellites, are hyperspectral infrared sounders which provide thousands of channels in each profile. They are used operationally in the global model ARPEGE and the limited-area model ALADIN since 2006 for AIRS and 2008 for IASI with a horizontal sampling of 250 km. However, only a subset of channels is used in the data assimilation. 54 channels are assimilated for AIRS over open sea and the number of IASI assimilated channels depends on the surface type: 64 over open sea, 50 over land and 32 channels over sea ice. These channels provide information on temperature roughly from 50 hPa down to 650 hPa.

In April 2010, the assimilated satellite data number have been increased by enhancing the horizontal sampling of the observations in the 3 operational models. In the global model ARPEGE, to assimilate 4 times more data, from 1 every 250 km to 1 every 125km, has shown a positive impact on forecasts for all variables and at all forecast ranges. The number of assimilated channels has also been increased for the IASI sounder. Four surface channels have been added over the sea for clear sky observations and 9 water vapour channels sounding in the upper-troposphere are assimilated over land and over the sea, leading to slightly positive impact on humidity for short forecast ranges (up to 24 hours).

As infrared spectra are strongly affected by the presence of clouds, their detection and characterization are of prime importance. At first, only clear channels were assimilated in the numerical weather prediction models. However, the sensitive areas where the cyclogenesis occur are mostly cloudy. In order to take into account the cloud effects in the simulation of the observation, a CO2slicing algorithm is used to retrieve a cloud-top pressure and a cloud fraction, which are then fed into the system to assimilate cloud-affected channels. This has been evaluated for AIRS spectra and led to an increase of the amount of used data and also to a positive impact on forecasts. Similar developments are in progress for IASI. As an example, figure 1 exhibits the cloud top pressure retrieved from IASI for the 24th of January 2009 around 00 UTC, when the storm named Klaus was approaching the French coast. The comma cloud shape associated with high level clouds and typical of severe storms is visible in the picture. A front located over the Atlantic Ocean is also seen. Tests of the cloudy IASI radiance assimilation have started in the global NWP model.

IASI and AIRS data have also been assimilated in the convective scale model AROME. Despite a rather poor temporal coverage of the domain, they exhibited a positive impact for upper air and surface fields at all time ranges up to 30h. The prediction of precipitation, which is a key point for AROME, has also been improved as shown by figure 2.

The next steps for the assimilation of hyperspectral souders will consist mainly in increasing their use over the continents and in characterizing land surface properties to enhance the assimilation of infrared sounders over land for all NWP models. Moreover, the horizontal density of spectra used in AROME will be specifically increased.

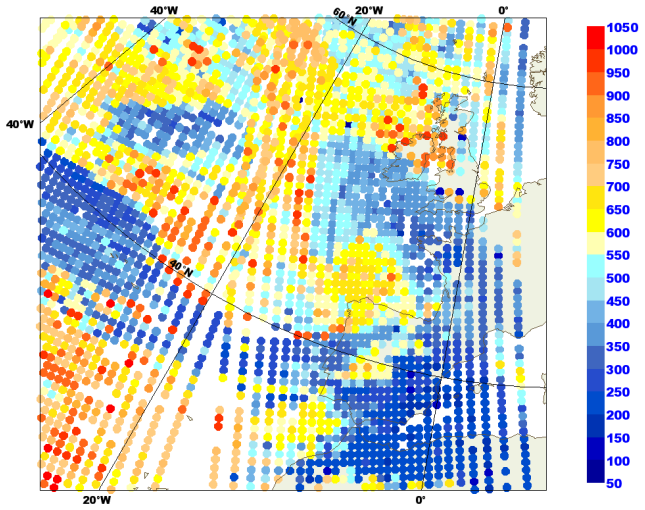
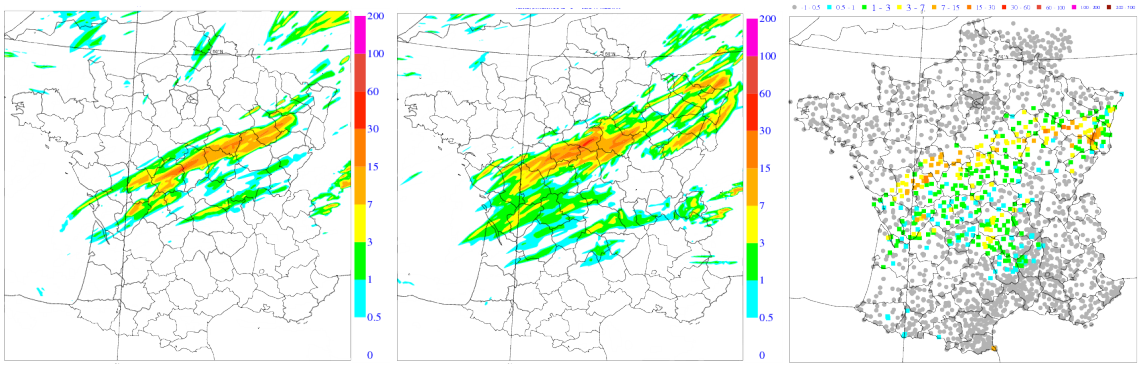


Figure 1: Cloud top pressure (in hPa) retrieved from IASI sounder with the ARPEGE model for the 24 january 2009 at around 00UTC.



a) b) c)

Figure_2: 12h precipitation accumulation as forecasted by AROME with no assimilation of AIRS nor IASI data (a), and with assimilation of AIRS & IASI data (b), to be compared with rain gauge measurements (c), for the period between 00 and 12 UTC on 21st of May 2009.